

Design and Development of a Low-cost Microcontroller Based Liquid Crystal Display (LCD) System for Electronic Instrumentation

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Abstract

A microcontroller based liquid crystal display (LCD) system has been designed and developed for digital message display. In the developed system a 20 x 4 alphanumeric with 5 x 7 dot matrix format liquid crystal display (LCD) was used. In this research work a microcontroller PIC16F84A was used for interfacing an alphanumeric dot matrix liquid crystal display. For initial display, an assembly language program was developed for a 3 lines single message display via LCD. By pressing the "ON" button of the system the LCD starts to show a three line still message at a time. The microcontroller has been programmed with assembly language program by using MPLAB IDE software.

Keywords: Liquid Crystal Display, LCD, Microcontroller, Assembly Language Program, MPLAB IDE Software.

1. INTRODUCTION

In many places, it requires to display message or outputs reading of the measuring instrument. If these systems are hardware controlled, they become inflexible and bulky. An alternative approach is to replace these kinds of circuits by using a microcontroller [1] and a few standard chips. The advantage of using microcontroller is that, it is a general purpose device which can be manufactured in vast numbers at low cost and then programmed for use in a wide variety of different instrument and control application [1] - [3]. As a result the electronics equipment may consist of just a few complex integrated circuits forming a compact module with the added advantage that the operation of the system can readily be tailored to satisfy the user's particular requirement. Thus, the advantages of a microcontroller based LCD display system are: 1) the system will allow the user to preset a wide variety of programs and may also be used to provide various monitoring functions at very low cost, 2) instruments incorporating a microcontroller can be made very flexible, 3) a microcontroller based system may achieve high accuracy, 4) it is faster than all other hardware controlled devices [2].

The objective of this research was to design and developed the necessary circuitry with PICF84A [4] microcontroller controlled by software to display the digital message on a LCD. There were two key components to the project design: (1) hardware to software interface (2) microcontroller assembly language software to drive the LCD. The block diagram of this system is shown in Fig. 1. This paper also provide the information about the PIC16F84A microcontroller, alphanumeric dot matrix 20 x 4 liquid crystal display, interfacing of LCD with microcontroller etc.

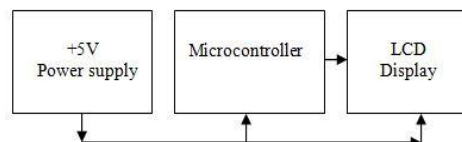


Fig. 1: Block Diagram of LCD Display System.

2. GENERAL OVERVIEW

This project work describes how to showing message the alphanumeric dot matrix liquid crystal display (LCD) with the PIC16F84A microcontroller. The used LCD displays have a standard ASCII set of characters [5] plus Japanese, Greek and mathematical symbols. The microcontroller is a highly integrated microprocessor designed specifically for use in embedded systems. Typically, this includes a CPU, RAM, some form of ROM, I/O ports, and timers [2]. Unlike a general-purpose computer, which also includes all of these components, a microcontroller is designed for a very specific task to control a particular system. PIC is a family of RISC microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division [6] – [10].

2.1. PIC16F84A Microcontroller

A microcontroller (or MCU) is a computer-on-a- single chip. It is a type of microprocessor emphasizing self-sufficiency and cost-effectiveness, in contrast to a general-purpose microprocessor (the kind used in a PC). The only difference between a microcontroller and a microprocessor is that a microprocessor has three parts - ALU, Control Unit and registers (like memory), but the microcontroller has additional elements like ROM, RAM etc. Fig. 2 represents the microcontroller's fundamental component.

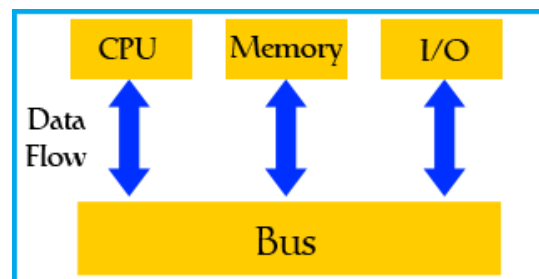


Fig. 2: Microcontroller's Fundamental Component

PIC (Peripheral Interface Controller) is the IC which was developed to control peripheral devices, alleviating the load from the main CPU. The PIC16F84A, uses the RISC(Reduced Instruction Set Computer). With this, the total number of instructions is 35. Fig. 3 and Fig. 4 represent the PIC16F84A microcontroller real picture and pin diagram of PIC16F84A respectively.



Fig. 3: PIC16F84A Microcontroller.

- _ watchdog timer;
- _ power-on reset;
- _ external crystal operation;
- _ 25mA current source/sink capability;
- _ power-saving sleep mode.

2.2. (20 x 4) Alphanumeric LCD Module

Fig. 5 represents the block diagram of a 20 x 4 LCD module and common connections with a controller. The modules utilize a 5 x 7 dot matrix format with cursor and are capable of displaying 160 different alphanumeric characters and symbols. The modules have LED backlighting.

2.3. Power Supply for LCD and Microcontroller

For a proper function of any microcontroller, it is necessary to provide a stable source of supply, a sure reset when you turn it on and an oscillator. According to technical specifications by the manufacturer of PIC microcontroller, supply voltage should move between 2.0V to 6.0V in all versions. The simplest solution to the source of supply is using the voltage stabilizer LM7805 which gives stable +5V on its output. In the current research we develop a power supply shown in Fig. 6.

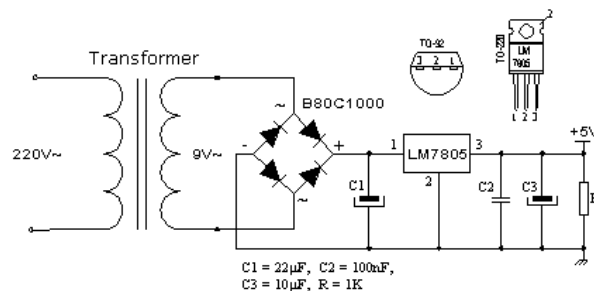


Fig. 6: Microcontroller and LCD Power supply circuit.

3. INTERFACING OF LCD WITH MICROCONTROLLER

Fig. 7 shows our developed system for the interfacing of LCD with a PIC16F84 microcontroller. In this circuit there is 8-bit data bus for displaying the message. For a 8-bit data bus, the display requires a +5V supply plus 11 I/O lines. For a 4-bit data bus it only requires the supply lines plus seven extra lines. When the LCD display is not enabled, data lines are tri-state which means they are in a state of high impedance (as though they are disconnected) and this means they do not interfere with the operation of the microcontroller when the display is not being addressed.

The LCD also requires 3 "control" lines from the microcontroller. The Enable (E) line allows access to the display through R/W and RS lines. When this line is low, the LCD is disabled and ignores signals from R/W and RS. When (E) line is high, the LCD checks the state of the two control lines and responds accordingly. The read-write (R/W) line determines the direction of data between the LCD and microcontroller. When it is low, data is written to the LCD. When it is high, data is read from the LCD. With the help of the Register select (RS) line, the LCD interprets the type of data on data lines. When it is low, an instruction is being written to the LCD. When it is high, a character is being written to the LCD.

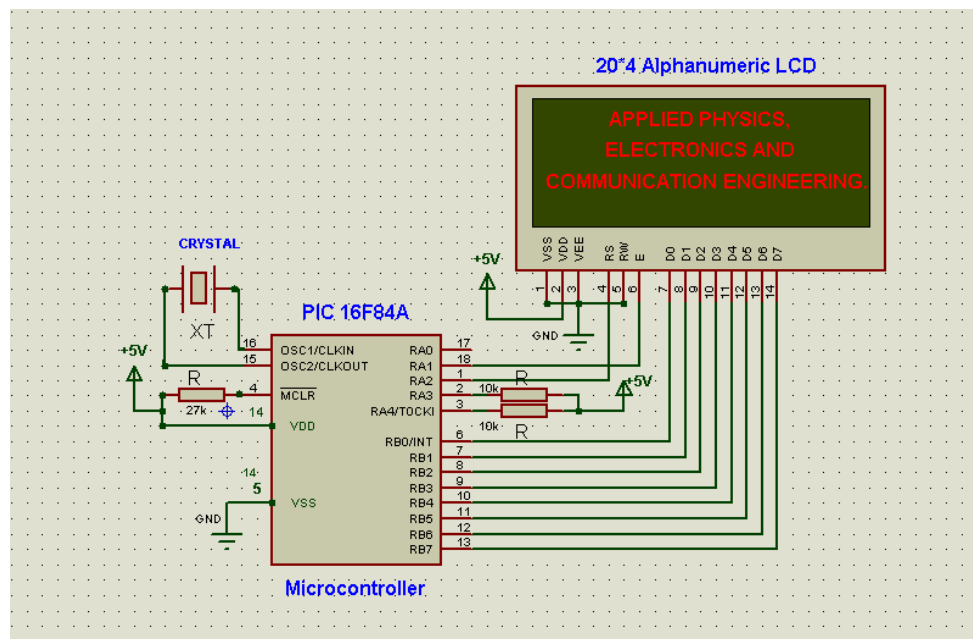


Fig. 7: Interfacing of LCD with Microcontroller

Reading data from the LCD is done in the same way, but control line R/W has to be high. When we send a high to the LCD, it will reset and wait for instructions. Typical instructions sent to LCD display after a reset are: turning on a display, turning on a cursor and writing characters from left to right. When the LCD is initialized, it is ready to continue receiving data or instructions. If it receives a character, it will write it on the display and move the cursor one space to the right. The Cursor marks the next location where a character will be written. When we want to write a string of characters, first we need to set up the starting address, and then send one character at a time. Characters that can be shown on the display are stored in data display (DD) RAM.

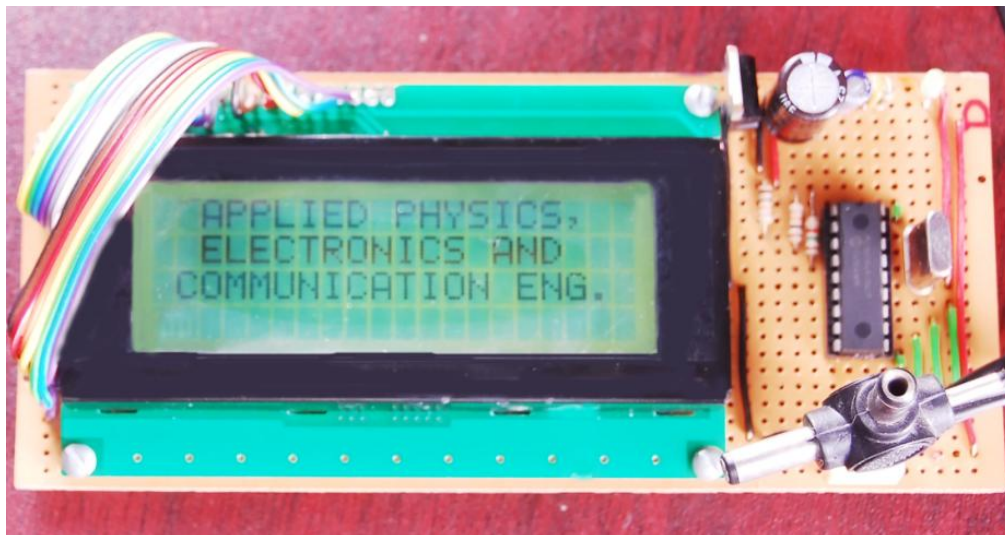


Fig. 8: Message Displayed on Liquid Crystal Display

Once the address of DD RAM is set, a new written character will be displayed at the appropriate place on the screen. Until now we discussed the operation of writing and reading to an LCD as if it were an ordinary memory. But this is not so. The LCD controller needs 40 to 120 microseconds (μ s) for writing and reading. Other operations can take up to 5 mS. During that time, the microcontroller can't access the LCD, so a program needs to know when the LCD is

busy. We can solve this in the way is to introduce a delay in the program. The delay has to be long enough for the LCD to finish the operation in process.

At the beginning we mentioned that we needed 14 I/O lines to communicate with an LCD. However, we can communicate with an LCD through a 8-bit data bus. The wiring connection via a 8-bit data bus is shown in the Fig. 8.

4. RESULTS AND DISCUSSION

This microcontroller based LCD display system has shown good performance. The used LCD display has the capability to show 4 character line messages at a time and each line message may consists maximum 20 characters. But in the current work it shows the message “APPLIED PHYSICS” in the first line. In the second line shows the message “ELECTRONICS AND”. And in the third line shows the message “COMMUNICATION ENG.”. Nothing was shown in the fourth line because the fourth line was not programmed for anything display. Therefore the total message shown by the LCD in the following format presented in Fig. 9.

A rectangular box with a thin black border. Inside the box, the text is centered and arranged in three lines. The first line reads "APPLIED PHYSICS,", the second line reads "ELECTRONICS AND", and the third line reads "COMMUNICATION ENG.".

Fig. 9: Output message format.

5. CONCLUSION

The system was developed by microcontroller, successfully display the desired output message. By using the microcontroller the system becomes simple, efficient and flexible. Since the microcontroller was controlled by software, the hardware complexity reduces tremendously. If modification of operation is needed it can be done very easily. The PIC microcontroller maintains the simplicity of the design, which in turn allows more features to be added at lower cost. Moreover by modification the developed system software it is possible to use the system for display moving message, scrolling message and also electronics instrumentation output result.

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